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Full and Half Scale Prototype Fabrication

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1. Introduction

There has been quite a bit of discussion within the NOVA collaboration about the need for the construction of a half and full scale prototype. The construction of a full scale prototype has been raised as an issue by the PAC. What is the purpose of such prototypes and what would we hope to learn from them? Are they necessary to understand structural properties and feasibility of construction of NOVA?

The three most important motivations for the construction of these prototypes are:

- To investigate and understand the details of the method of construction. How difficult is it to glue large panels together? What flatness is needed for the lifting fixture? How is compression between panels achieved? What is the glue line thickness? How flat will the planes be after construction? Will the panels conform to the shape of the previously glued panels? Can a good glue bond be achieved between an 8 plane stack and the previously installed stack? How is the 8 plane stack held in place when placed against the spacers on the previously assembled block of 32 planes? What glue coverage can be achieved or is needed?
- To understand the structural stability of an empty 8 plane stack. An 8 plane stack is currently the basic building block for the detector, how stable is this stack during lifting? Can it stand on its own without buckling? Can it be pressed sufficiently against previously constructed stacks to get a good glue bond? How flat is a stack? How straight/vertical can this stack is positioned?
- To understand the mechanical performance of a stacked set of planes when filled with liquid. After construction the prototype would be filled with liquid in order to measure deformation and compare them to calculated values.

2. Large Prototypes vs. small scale tests

Are large prototypes needed to answer the questions described above? Could small scale tests and calculations be enough to understand the mechanical performance of NOVA and address these questions?

Several critical questions about the construction methods can only be answered by a large scale prototype. Only a prototype that is a minimum of half scale is large enough to address questions about the stiffness of a stack, the ability to compress stacks and large extrusions together during gluing. Similarly, only a large prototype can investigate the stability of the structure. The successful construction of NOVA depends upon the ability of gluing a stack (2 layers, 8 layers???) on a lifting fixture lying horizontal on the floor and then raising this stack and gluing it to previously assembled stacks. The success of this operation depends upon having a good understanding of the stiffness of the stack, its stability in the vertical position, understanding how sufficient compression can be obtained to achieve a consistent and even glue bond across a large area, and understanding how such a large structure can be sufficiently pressed against the previously assembled stacks to achieve a good glue bond. These questions can only be answered by a large prototype.

Finally, the mechanical performance of the NOVA structure when filled with liquid is critical. Calculations to date have shown that the majority of the deformations and stresses only occur in the bottom 60" of the structure. It could be possible to construct a prototype that is only 15ft high, fill it with liquid and then pressurize the liquid in order to achieve the design pressure at the bottom of the extrusions. However, the deformation of the structure is heavily dependent upon the weight of the extrusions (i.e. the extrusion weight causes the locking of the extrusions on the floor from friction).

3. Half-Scale prototype

At ANL a half scale prototype is currently being constructed using commercially available extrusions from Extrutech. These extrusions have a smaller cell and thinner wall than the current NOVA design. The main purpose of this prototype has always been to investigate the questions about the construction methods and feasibility of NOVA. This prototype is sufficiently large to provide important information about glue line thicknesses that can be achieved, the difficulty of compressing large panels together, the flatness of the panels before and after gluing, and the stiffness of a large structure. The bookend that has been constructed will be measured for flatness before any extrusions planes are assembled.   After the first 2 planes are assembled the flatness will be measured again and compared to the initial flatness of the wall. This will provide information on how difficult it is to get a set of panels sufficiently compressed against an existing structure. Before this gluing, a series of tests are going to be performed on a dry stack to measure glue distribution and the compressive force on the wall. These tests and measurements will be repeated when the next 2 planes are added.

Also, a FEA analysis of the structure filled with liquid will be compared to the actual structure. Strain gages will be used to measure the stresses at key points in the structure and the deformation across the surface will also be measured and compared to the deformations predicted by the FEA. Finally, thin pressure sensors will be placed throughout the structure in order to measure the amount of compression that is achieved between planes during assembly.

4. Full -Scale prototype.

A full-scale prototype is needed in order to investigate all of the questions raised previously about the assembly of the structure and stiffness of an 8 plane stack and the completed structure. A minimum of 40 planes should be assembled. The first 32 planes could be assembled against a strongback, the last 8 planes would be assembled against the spacers that are placed on the first 32 planes to form a gap that is needed to prevent deformations being transferred between planes. A full scale prototype does not have to be full width, but it does have to be sufficiently wide so that edge effects are not observed and any difficulties associated with lifting a large surface and attempting to keep it flat and compressed can still be seen. A width of 25ft is probably sufficient to achieve structural stability.

One of the limiting factors for constructing a full scale prototype is the lifting fixture that would be needed. Such a fixture does not have to be expensive. This fixture could be fabricated from steel open joists that are pre-fabricated and can easily provide a very stiff truss structure that spans 50ft. A preliminary investigation of these joists has shown that standard joists can be found which will produce very small deflections (>1") over 50ft. This device can be raised by simply using a winch in a manner similar to that used on the ANL half scale prototype. Existing winches are sufficient to raise this structure. A preliminary design still has to be completed but it is felt that such a fixture could be constructed for $20-30k. It is likely that the same concepts could then be incorporated into the final lifting structure that will be used in production, resulting in substantial cost savings over the fixture described in the NOVA proposal..

5. Conclusion

Both half and full scale prototype construction are critical to understanding the structural performance of the NOVA detector and would provide important understanding of the methods of assembly. The half scale prototype is currently being constructed at ANL and the full scale prototype can be constructed for relatively little cost. The half scale prototype will provide important information on the assembly of the NOVA structure and planning should begin to build a full scale prototype as soon as the PVC specifications have been decided.